Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Clinical Anaesthesia

Journal homepage: www.ijca.in

Original Research Article

Transverse ultrasound scanning of lumbar-epidural depth and its co-relation with conventional method: A prospective observational study in obese Indian parturients

Amit Kumar Chauhan[1], **Shreesh Mehrotra**[1], **Rohan Bhatia**[1]*, **Neeru Yadav**[1]

[1] *Dept. of Anaesthesia, Himalayan Institute of Medical Sciences, Dehradun, Uttarakhand, India*

ARTICLE INFO

Article history:
Received 24-06-2024
Accepted 05-07-2024
Available online 30-08-2024

Keywords:
Transverse plane
Obese parturient
Lumbar epidural
Ultrasound
Needle depth
Ultrasound depth

ABSTRACT

Background: Pre-procedural ultrasound (US) imaging as a tool of determining the proper insertion site and assessing lumbar-epidural depth in obese Indian parturients.

Objectives: The current study's goal was to assess the epidural depth space in obese Indian parturients by ultrasound imaging with conventional technique and also to assess whether if it decreases the failure rate and number of attempts.

Materials and Methods: Twenty-five obese parturients with a BMI of more than 30 kg/m^2 who were scheduled for elective lower segment caesarean sections under lumbar epidural anesthesia and were classified as American Society of Anaesthesiology grade I & II were included. Using a curvilinear US probe (frequency 2–5 MHz), ultrasound depth-UD (lumbar epidural) was recorded in the transverse axial plane at the L3–L4 and L4–L5 intervertebral regions. Afterwards, the needle depth (ND) was monitored using a sterile linear scale during the epidural administration process using the traditional loss of resistance (LOR) approach. Any modifications to the intervertebral spacing, needle reorientation, or the quantity of tries were recorded.

Results: The results showed that UD and ND were, respectively, 4.6140 ± 0.252 cm (range 4.20–5.30 cm) and 4.720 ± 0.271 cm (range 4.2–5.5 cm). Pearson's correlation coefficient (r) for UD and ND was 0.953 (95% confidence interval: 0.8948–0.9793, $r^2 = 0.908$, $P < 0.001$), and the 95% limits of agreement were found to be 0.266 to 0.546 cm using Bland-Altman analysis. Of all the subjects, 92% needed only one try to put the epidural, whereas 8% needed two.

Conclusion: The current study demonstrates a significant association of ultrasound (UD) and needle depth (ND) in obese pregnant females (BMI >30 kg/m^2). For lumbar epidurals, a preprocedural US scan in the transverse-axial plane provides a precise needle entry site with a high success rate.

1. Introduction

The use of ultrasound (US) in regional anesthesia has grown due to its ease of use, ability to confirm landmarks, and ability to precisely deposit local anesthetic. These benefits come with a lower risk of complications and an increased level of safety.[1] Due to their ease of use and historical educational approach, millions of neuraxial blocks are carried out as blind, tactile procedures worldwide; nevertheless, ultrasound use for central neuraxial blocks, epidural, or spinal anesthesia is still lagging behind.[1,2] When diagnosing lumbar-epidural depth using the loss of resistance approach, the excess of fat and oedema of ligaments and soft tissues due to pregnancy may raise the false-positive rate.[3] The failure rate for labour epidural analgesia varies between 1.5% and 20% reported in previous

* *Corresponding author*.
E-mail address: rohanbhatia789@gmail.com (R. Bhatia).

https://doi.org/10.18231/j.ijca.2024.063

studies.[4] The implementation of this relatively "blind" technique is significantly hampered in obese women; reports of high failures, lengthier procedure times and other complications have been reported.[3] In addition to assisting in determining the epidural insertion point and estimating the needle's orientation during insertion, ultrasound guidance for epidural implantation may also be used to measure the lumbar-epidural depth in obese patients.[4] The transverse approach is simpler to use, provides a high-quality image for labour epidurals, and is sufficiently dependable to be learned.[5] Prior to the insertion of the Touhy's needle with LOR technique, ultrasound scanning of the epidural space lowers the attempts and rate of epidural catheter replacements for unsuccessful labour analgesia.[4] Ultrasonography in recent days is generating considerable interest because of its potential use as a pre-operative tool for neuraxial blockade and for its use in lumbar regional anesthesia.[6,7]

The US can be difficult to use at times, particularly for patients who are obese or elderly.[8,9] The epidural depth is often accessed by lumbar epidural catheterizations; failure to do so may result in insufficient analgesia, loss of diagnostic data, or difficulty administering medication.[10,11] Up to 30% of lumbar epidural blocks may have incorrect needle placement when using the LOR technique, according to research.[12] This happens as a result of the considerable fluctuation in the distance between the skin and the surface anatomical references of the epidural depth space, which might make it difficult to accurately identify the space.[13] This error raises the possibility of multiple injection attempts, hematoma formation, nerve damage, paraesthesia, and a significant chance of postdural puncture headaches.[14,15] Based on these challenges in localizing the epidural space in obese parturients, we aimed a prospective observational study to evaluate the skin-epidural space distance as assessed by US-ultrasound depth (UD) versus conventional LOR technique i.e. needle depth (ND) and its correlation with body mass index (BMI) >30 kg/m^2 in obese Indian parturients posted for elective lower segment caesarean section under lumbar epidural anesthesia.

2. Materials and Methods

Following clearance from the Institutional ethics committee - SRHU/HIMS/E-1/2024/02 (CDSO Registration No. ECR/1741/Inst/UK/2022 & ICMR Registration No. EC/NEW/INST/2022/UA/0152), this prospective observational study was carried out in a tertiary care hospital. A total of 25 obese parturients, aged 20–40 year, from American Society of Anaesthesiology (ASA) Grades I and II with a BMI >30 kg/m^2 undergoing elective lower segment caesarean sections under epidural anesthesia were included in this study after obtaining the written and informed consent. A thorough preoperative assessment was done, and ASA grade, height, age, weight, and BMI were noted. This study excluded participants who refused epidural anesthesia during pregnancy, had a history of neurological disorders, had prior spinal surgery, had spinal abnormalities, had an infection at the puncture site, had coagulopathies, or were otherwise contraindicated for neuraxial block. All of the parturients adhered to the recommended normal fasting durations, which are two hours for clear, transparent liquids and six hours for solid foods. A 20 gauge intravenous canula was placed in the non-dominant hands of each parturient in the pre-operative room, and 10 millilitres per kilogram of balanced salt solutions were co-loaded into each one. Throughout the peri-operative phase, all common non-invasive parameters including temperature, oxygen saturation, blood pressure, and electrocardiography were tracked. The procedure (lumbar-epidural) was done on the parturient in sitting position. Using 6% chlorhexidine antiseptic solutions, the skin was thoroughly washed, and a disposable sterile cut sheet was used to drape the region. Palpation method was applied to find the L3–4 interspace in accordance with Tuffier's line. Ultrasound-guided spinal imaging was performed in the transverse plane at the L3-L4 and L4-L5 intervertebral spaces by a board-certified anaesthesiologist with more than five years of experience. A portable ultrasound Sonosite (M-Turbo) 21919-USA frequency of 2–5 MHZ curvilinear transducer was utilized for scanning. The US probe was positioned in the transverse plane horizontally relative to the lumbar spine's long axis. (Figure 1) The spinous process seen as a tiny bright-hyperechoic signal, which corresponds to the vertebrae's midline. Just below the skin's surface, a lengthy, triangular, dark-hypoechoic acoustic shadow was observed. To get the best image, the ultrasonic probe was moved either cephalically or caudally, identifying the Anterior Complex (AC), which consisted of the posterior longitudinal ligament and vertebral body, and the Posterior Complex (PC), which was composed of the ligamentum-flavum dura mater. A hyperechoic "=" symbol in the middle of the interspace was perceived as PC and AC. Rather than ligamentum flavum and dura mater separately, the ligamentum flavum-dura mater (PC) served as the reference point. The US's integrated calliper is used to gauge the separation between the skin and the PC, or ligamentum flavum-dura mater complex, inner surface. (Figure 2) The midpoint of the right lateral vertical surface of the probe and the midline of the top horizontal surface intersected to mark the location of the Tuohy epidural needle insertion on the skin. At the exact insertion site that the US had determined, the needle was placed. Using the traditional LOR method, another anaesthesiologist who was not familiar with US epidural depth performed epidural space localization. After administering the anaesthetic drug, sterile linear scale was used to measure the ND. It was also recorded if any change in needle direction, number of attempts, any other

complication or the intervertebral space changed.

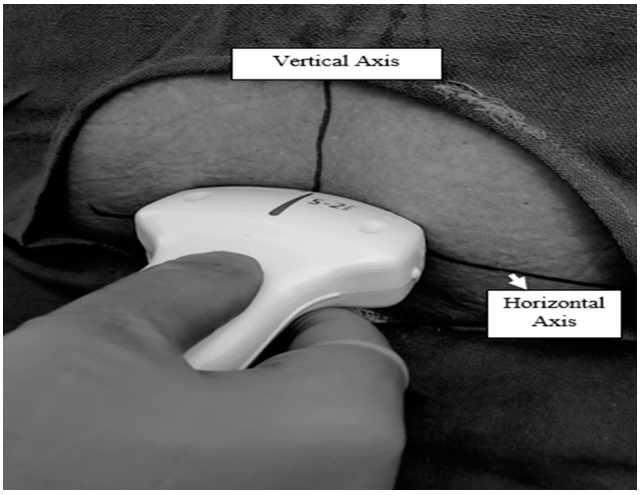

Figure 1: Needle insertion site at the intersection of Horizontal and Vertical axis

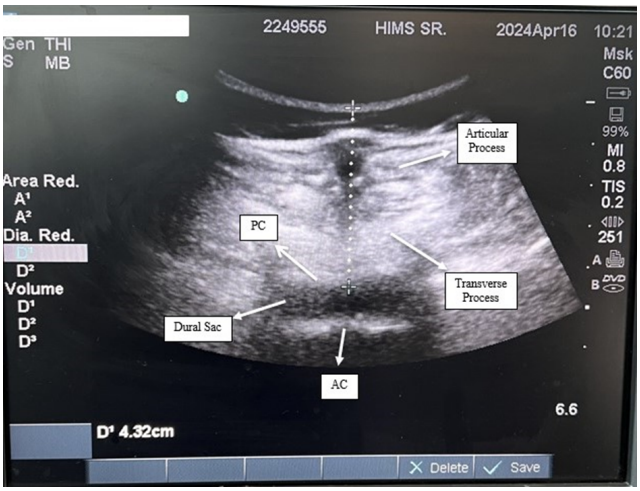

Figure 2: Ultrasound image in transverse plane. Midline bright hyperechoic ("=" sign) structure represent the posterior complex (PC) and anterior complex (AC)

2.1. Sampling method and statistical analysis

Bivariate associations were used to perform sampling calculations for the association tests. In parturients who were obese, a significant correlation was found between the lumbar epidural depth as assessed by ultrasonography (UD) and traditional methods (ND) and considered meaningful.[3–5] A total of 20 analyzable subjects provided 99% power to determine that the correlation is statistically different from zero at the 0.05 level, in order to identify a moderate correlation (r = 0.80). The following formula was used to determine the sample size for the study:

$N = [(Z\alpha+Z\beta)/C]^2 + 3$

N is sample size numbers

Where,

The standard normal deviation for $\alpha = Z\ \alpha = 1.96$

The standard normal deviation for $\beta = Z\ \beta = 2.54$

$C = 0.5 * \ln[(1+r)/(1-r)]$

$= 0.5*\ln[1.80/0.20]$

$= 0.5*0.20$

$= 1.10$

$N = [(1.96+2.54)/1.10]\ 2 + 3$

$= [4.54/1.10]\ 2 + 3$

$= 17.07+3 = 20.07$

To make up for any dropouts, we enrolled a total of 25 participants in our study. With SPSS version 28.0, the descriptive analytic statistics were completed. The continuous variables were shown as mean ± SD or as median (IQR). Frequencies and percentages were used to express categorical variables. To determine if two category variables are associated, the Pearson's chi-square test, also referred to as the chi-square test of association, was utilized. In obese subjects, lumbar epidural depth measured by ultrasound imaging and traditional methods was correlated using a Spearman-Pearson method. The agreement between the ultrasonic depth and needle depth is shown by the Bland-Altman plot. For all statistical tests, a p value of less than 0.05 was considered statistically significant.

3. Results

Twenty-five parturients who met the study protocol's requirements were enrolled in this research. The parturients' various variables are shown in (Table 1).

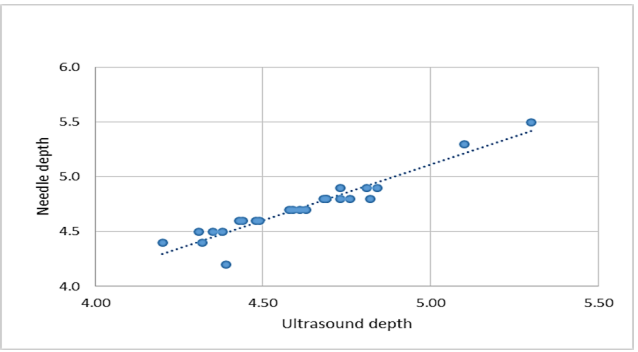

Figure 3: Overall agreement between ultrasound depth and needle depth. The solid dotted line is the regression analysis showing UD versus ND. All the data lying along the dotted line, indicative of high degree linear relationship between two variables

Only elective lower segment caesarean sections, or obstetric surgery, were chosen as part of the surgical operations. Out of 25 parturients, 23 (92.0%) were in the obesity class I range between 30 and 34.9 kg/m^2, and 2 parturients (8%) were in the obesity class II range, i.e., between 35 and 39.9 kg/m^2 as per the WHO classification.

Table 1: Variables of parturients

Variables	Mean ± SD	Range	Median	IQR
Patients' age (year)	29.68 ± 3.966	22-38	30	26.5-32.5
Height (cm)	155.36 ± 3.818	148-162	156	152-157.5
Weight (kg)	78.928 ± 4.691	71-89	77.928	74.80-82.55
BMI (kg/m2)	32.744 ± 1.347	30.9-36.1	32.60	31.6-33.35
UD (cm)	4.6140 ± 0.252	4.20 - 5.30	4.610	4.41-4.74
ND (cm)	4.720 ± 0.271	4.20 - 5.50	4.70	4.55-4.80

BMI: Body mass index; UD: Ultrasound depth; ND: Needle depth; SD: Standard deviation; IQR: Interquartile range

Table 2: Agreement between ultrasound depth and needle depth

BMI	Pearson's correlation	Value
BMI (n=25)- 30.9-39.9 kg/m2	Pearson's correlation Coefficient (r)	0.953
	95% CI	0.8948 – 0.9793
	P value	< 0.0001

n: Number of patients. CI: Confidence interval; BMI: Body mass index

Table 3: Needle redirection

Number of attempts	Frequency	%	Needle Redirection	Frequency	%
1	23	92%	Cephaled	2	8%
2	2	8%	Caudal	0	0.0%

%: Percentage

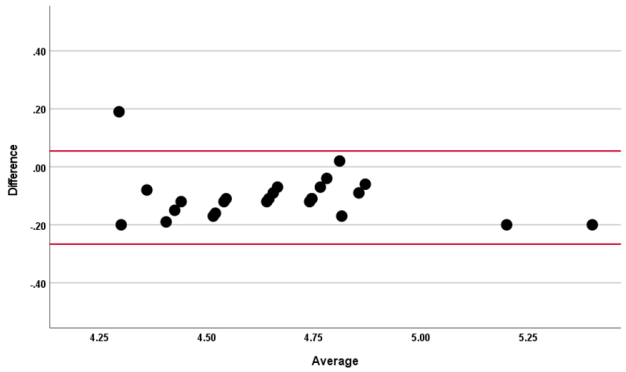

Figure 4: The Bland-Altman plot demonstrates the agreement between ultrasound and needle depth measurements. It typically features the difference between the two measurements on the y-axis and the average of the two measurements on the x-axis. The upper 95% confidence limit was 0.546 cm, and the lower limit was-0.266 cm

The overall average mean BMI was 32.744 ± 1.347, and the median (IQR) was 32.60 (31.6-33.35) kg/m^2. The mean UD was 4.6140 ± 0.252 cm and the median (IQR) was 4.610 (4.41-4.74) cm, whereas the mean ND was 4.720 ± 0.271 cm and the median (IQR) was 4.70 (4.55-4.80) cm. The measures' mean difference ± standard error of mean (− 0.106 ± 0.074 cm, 95% CI: −0.043–0.255, P = 0.159) did not demonstrate statistical significance. The Pearson's correlation value (r) between the UD and ND was 0.953 (95% CI: 0.8948–0.9793, r2 = 0.9082, P < 0.001), and the best-fit line on the UD versus ND graph showed a significant linear link between the two variables. (Figure 3), Whereas the 95% limit of agreement, as determined by Bland-Altman analysis revealed −0.266–0.546 cm (Figure 4). In all 25 (100%) obese parturients, BMI range of 30-39.9 kg/m^2, we identified a correlation coefficient value of r = 0.953, P < 0.001, in b/w UD & ND, indicating a strong and significant link (Table 2).

Out of 25, 92.0% (23) parturients in this study had their epidural needles placed without the need for any reinsertions, while 8.0% (2) parturients needed two insertion attempts in the cephaled direction (Table 3). These two parturients were with BMI >35.0 kg/m2, i.e., they were in the obesity class II range.

4. Discussion

The anatomical landmarks required for tactile epidural space localization are usually obscured by obesity. The presence of extra tissue may increase the false-positive rate when the loss-of-resistance technique is employed to detect epidural depth space. These factors explain a higher probability of technical difficulties, a higher number of needle tries, a higher risk of needle reangulation, and other issues such as bleeding, dural tap, ineffective block, etc.[3,4] In our study we observed a strong and significant correlation

between UD and ND in obese Indian parturients. These results align with findings from studies by Balki et al. and Arzola et al., where both studies reported a high success rate in pinpointing the epidural insertion site using ultrasound, and excellent agreement between the distances measured from the skin to the epidural space by ultrasound and needle puncture methods.[3,5]

In our study only 2 (8%) parturients required reangulation while the rest 23 (92%) parturients had a successful epidural block in first attempt which was similar to the meta-analysis and systemic review by Young B et al. They showed increased measures of efficacy, such as the first-pass success rate, with preprocedural ultrasonography. In addition, they proposed that preprocedural ultrasound, as compared to palpation of anatomical landmarks, further reduced the incidence of complications, such as unable to site the neuraxial block technically; analgesia or anesthesia failure; "bloody tap" or vascular cannulation; and headache and back pain following childbirth.[16] In obese parturients undergoing caesarean delivery, Sahin et al. and Wang et al. showed an enhanced first-attempt success rate and a decreased number of needle attempts with ultrasonography in spinal and CSE methods, respectively.[17,18]

While placing difficult epidural and spinal blocks, ultrasound guidance used in pre-procedure scanning is a useful tool. This is especially true for patients who are morbidly obese, have significant scoliosis, or have a history of prior spine procedures and instrumentation.[1] Ultrasound may reduce the frequency of procedure-related adverse events if technical difficulties are anticipated.[19] The needle reangulation observed in two participants in our study can be attributed to their BMI >35 kg/m^2. Even with the guidance of ultrasound scanning, the excess fat contributed to increased difficulty to predict the appropriate insertion point. Moreover, it was observed that in these class II obese participants, the UD was >5 cm and the US image was not so clear, which probably led to more needle attempts.

In a study conducted in our institute, we found that pre-procedural US was a good tool for epidural depth assessment in non-obese patients.[20] To overcome this limitation, we conducted this study on obese Indian parturients, and it proved to be useful for epidural depth evaluation in participants with a BMI > 30 kg/m^2.

In a different study, Ansari et al. found that there was no statistically significant difference in the amount of time required to identify the subarachnoid space, the number of skin punctures or needle passes, the incidence of headaches or backaches, or patient satisfaction between the use of ultrasound and the conventional method to perform spinal anesthesia.[21]

Our study is constrained by the limited number of class II obese patients (>35 kg/m^2), which affected our ability to draw conclusions specifically for this group. Additionally, we were unable to evaluate the time required to identify the epidural space using ultrasonography and compare it with the conventional method.

5. Conclusion

Pre-procedural ultrasound imaging significantly enhances the success rate and reduces complications of lumbar epidural anaesthesia in obese Indian parturients undergoing elective lower segment caesarean sections. By providing clear visualization of anatomical landmarks, ultrasound guidance helps anesthesiologists accurately place the epidural needle, overcoming the challenges posed by obesity. This approach leads to improved patient outcomes and increased procedural safety.

6. Sources of Funding

None.

7. Conflict of Interest

None.

Acknowledgments

The department of Anaesthesia and department of Obstetrics & Gynaecology, our patients and technical staff, for their continuous support and encouragement in helping us carry out this study.

References

1. Teissler HH, Lozano C, Plavsic KS. The use of ultrasonography for the guidance of epidural analgesia in obstetric anesthesia. *Donald Sch J Ultrasound Obstet Gynecol*. 2014;8:44–51.
2. Reynolds F. Damage to the conus medullaris following spinal anaesthesia. *Anaesthesia*. 2001;56(3):238–47.
3. Balki M, Lee Y, Halpern S, Carvalho JC. Ultrasound imaging of the lumbar spine in the transverse plane: The correlation between estimated and actual depth to the epidural space in obese parturients. *Anesth Analg*. 2009;108:1876–81.
4. Vallejo MC, Phelps AL, Singh S, Orebaugh SL, Sah N. Ultrasound decrease the failed labor epidural rate in resident trainees. *Int J Obstet Anesth*. 2010;19(4):373–8.
5. Arzola C, Davies S, Rofaeel A, Carvalho JC. Ultrasound using the transverse approach to the lumbar spine provides reliable landmarks for labor epidurals. *Anesth Analg*. 2007;104:1188–92.
6. Provenzano DA, Narouze S. Sonographically guided lumbar spine procedures. *J Ultrasound Med*. 2013;32(7):1109–16.
7. Chin KJ, Chan V. Ultrasonography as a preoperative assessment tool: Predicting the feasibility of central neuraxial blockade. *Anesth Analg*. 2010;110(1):252–3.
8. Shankar H. Ultrasound-guided steroid injection for obturator neuralgia. *Pain Pract*. 2008;8(4):320–3.
9. Darrieutort-Laffite C, Bart G, Planche L, Glemarec J, Maugars Y. Usefulness of a pre-procedure ultrasound scanning of the lumbar spine before epidural injection in patients with a presumed difficult puncture: A randomized controlled trial. *Joint Bone Spine*. 2015;82(5):356–61.
10. Shaikh F, Brzezinski J, Alexander S, Arzola C, Carvalho JC, Beyene J, et al. Ultrasound imaging for lumbar punctures and epidural catheterisations: Systematic review and meta-analysis. *BMJ*. 2013;346:346:f1720.

11. Shah KH, Richard KM, Nicholas S, Edlow JA. Incidence of traumatic lumbar puncture. *Acad Emerg Med*. 2003;10(2):151–4.
12. Pak MH, Lee WH, Ko YK, So SY, Kim HJ. Ultrasonographic measurement of the ligamentum flavum depth; is it a reliable method to distinguish true and false loss of resistance? *Korean J Pain*. 2012;25(2):99–104.
13. Helayel PE, Conceição DBD, Meurer G, Swarovsky C, Filho G. Evaluating the depth of the epidural space with the use of ultrasound. *Rev Bras Anestesiol*. 2010;60(4):376–82.
14. Filho GRD, Gomes HP, Fonseca MHD, Hoffman JC, Pederneiras SG, Garcia JHS. Predictors of successful neuraxial block: a prospective study. *Eur J Anaesthesiol*. 2002;19(6):447–51.
15. Gnaho A, Nguyen V, Villevielle T, Frota M, Marret E, Gentili ME. Assessing the depth of the subarachnoid space by ultrasound. *Rev Bras Anestesiol*. 2012;62(4):520–30.
16. Young B, Onwochei D, Desai N. Conventional landmark palpation vs. preprocedural ultrasound for neuraxial analgesia and anaesthesia in obstetrics - a systematic review and meta-analysis with trial sequential analyses. *Anaesthesia*. 2020;76(6):818–31.
17. Sahin T, Balaban O, Sahin L, Solak M, Toker K. A randomized controlled trial of preinsertion ultrasound guidance for spinal anaesthesia in pregnancy: outcomes among obese and lean parturients: ultrasound for spinal anesthesia in pregnancy. *J Anesth*. 2014;28(3):413–9.
18. Wang F, Lü Q, Wang M, Xu H, Xie D, Yang Z. Ultrasound-guided caudal anaesthesia combined with epidural anaesthesia for caesarean section: a randomized controlled clinical trial. *BMC Pregnancy Childbirth*. 2024;24(1):105.
19. Schnabel A, Schuster F, Ermert T, Eberhart LH, Metterlein T, Kranke P. Ultrasound guidance for neuraxial analgesia and anesthesia in obstetrics: a quantitative systematic review. *Ultraschall Med*. 2010;33(7):E132–E13.
20. Chauhan AK, Bhatia R, Agrawal S. Lumbar epidural depth using transverse ultrasound scan and its correlation with loss of resistance technique: A prospective observational study in Indian population. *Saudi J Anaesth*. 2018;12(2):279–82.
21. Ansari T, Yousef A, Gamassy AE, and MF. Ultrasound-guided spinal anaesthesia in obstetrics: is there an advantage over the landmark technique in patients with easily palpable spines? *Int J Obstet Anesth*. 2014;23(3):213–6.

Author biography

Amit Kumar Chauhan, Assistant Professor https://orcid.org/0000-0001-5652-5031

Shreesh Mehrotra, Associate Professor https://orcid.org/0000-0002-5299-3070

Rohan Bhatia, Professor https://orcid.org/0000-0002-1270-6241

Neeru Yadav, Senior Resident https://orcid.org/0000-0002-3662-040X

Cite this article: Chauhan AK, Mehrotra S, Bhatia R, Yadav N. Transverse ultrasound scanning of lumbar-epidural depth and its co-relation with conventional method: A prospective observational study in obese Indian parturients. *Indian J Clin Anaesth* 2024;11(3):328-333.